NPS Form 10-900
(7-81)

United States Department of the Interior
National Park Service

National Register of Historic Places Inventory—Nomination Form

For NPS use only
received
date entered

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

1. Name

historic Lunar Landing Research Facility

and/or common Impact Dynamics Research Facility

2. Location

street & number Langley Research Center ___ not for publication

city, town Hampton ___ vicinity of **congressional district**

state Virginia **code** 51 **county** Hampton **code** 650

3. Classification

Category	Ownership	Status	Present Use	
___ district	_X_ public	___ occupied	___ agriculture	___ museum
___ building(s)	___ private	___ unoccupied	___ commercial	___ park
_X_ structure	___ both	___ work in progress	___ educational	___ private residence
___ site	**Public Acquisition**	**Accessible**	___ entertainment	___ religious
___ object	___ in process	_X_ yes: restricted	_X_ government	_X_ scientific
	___ being considered	___ yes: unrestricted	___ industrial	_X_ transportation
		___ no	___ military	_X_ other: Aeronautical Research

4. Owner of Property

name National Aeronautics and Space Administration (NASA)

street & number

city, town Washington ___ vicinity of **state** D.C. 20546

5. Location of Legal Description

courthouse, registry of deeds, etc. National Aeronautics and Space Administration (NASA)

street & number Real Property Management Office Code NXG

city, town Washington **state** D.C. 20546

6. Representation in Existing Surveys

title None **has this property been determined eligible?** ___ yes ___ no

date ___ federal ___ state ___ county ___ local

depository for survey records

city, town **state**

7. Description

Condition		Check one	Check one
X excellent	___ deteriorated	___ unaltered	X original site
___ good	___ ruins	X altered	___ moved date _____
___ fair	___ unexposed		

Describe the present and original (if known) physical appearance

The Lunar Landing Research Facility is in the West Area of the Langley Research Center. This facility was constructed in 1965 at a cost of $3.5 million and was used by the Apollo astronauts as a training simulator to study and practice piloting problems in the final phase of the lunar landing mission. A list of the Apollo astronauts that trained on the Lunar Landing Research Facility can be found in Appendix A at the rear of this nomination.

The Lunar Landing Research Facility is an A-frame steel structure 400 feet long and 230 feet high. Associated with this facility is a full-scale Apollo Lunar Excursion Module or LEM. Simulation of lunar gravity is achieved by employing an overhead partial-suspension system which provides a lifting force by means of cables acting through the vehicle's center of gravity so as to effectively cancel all but one-sixth of earth's gravitational force. The lifting force and vertical alignment of the cables are controlled automatically through the action of servo-controlled hydraulic drive systems which power the overhead traveling bridge crane and dolly unit mounted on the large gantry structure. The bridge follows in the down-range motion of the vehicle, and the under-slung dolly follows in the cross-range direction.[1]

The cables are attached to the vehicle by means of a gimbal system which provides freedom of motion in pitch, roll, and yaw. This system consists of a swiveled-truss assembly directly over the cab and two vertical struts attached to the vehicle on its pitch axis. Load cells are carried in the vertical struts to sense cable force for the lift servo system, and cable angle sensors are mounted on the bottom of the dolly to provide error feedback signals for the bridge and dolly servo drive systems. Automatic braking equipment built into the servo drive units provide an extra safety feature. The LEM can fly in a space of about 180 feet high, by 360 feet long, and 42 feet wide.[2]

The LEM was constructed using many pieces of off the shelf equipment such as the H-34 helicopter cabin and landing gear shock struts. Nitrogen gas was used to pressurize the fuel system which provided 90 percent hydrogen peroxide to the main lifting body rocket assembly and to the 20 attitude rocket motors located around the periphery of the vehicle frame. The cab of the LEM can accommodate two persons at the same time. A common instrument panel is mounted between the two pilots. Attitude controls at the right hand seat consist of a set of standard foot pedals for yaw control and a two-axis side-arm controller used for pitch and roll control. The left hand seat is provided with a three-axis side arm controller. Thrust of the main engines is controlled by either pilot with his left hand using the collective pitch levers. Weight of the vehicle is 12,000 pounds, of which 3300 pounds was hydrogen peroxide fuel, giving a flight duration of slightly less than three minutes.[3]

8. Significance

Period	Areas of Significance—Check and justify below				
___ prehistoric	___ archeology-prehistoric	___ community planning	___ landscape architecture	___ religion	
___ 1400–1499	___ archeology-historic	___ conservation	___ law	___ science	
___ 1500–1599	___ agriculture	___ economics	___ literature	___ sculpture	
___ 1600–1699	___ architecture	___ education	___ military	___ social/ humanitarian	
___ 1700–1799	___ art	X engineering	___ music	___ theater	
___ 1800–1899	___ commerce	___ exploration/settlement	___ philosophy	X transportation	
X 1900–	___ communications	___ industry	___ politics/government	X other (specify) Space Exploration	
		___ invention			

Specific dates 1965-1972 **Builder/Architect** NASA

Statement of Significance (in one paragraph)

The Lunar Landing Research Facility permitted NASA to train the Apollo astronauts to fly in a simulated lunar environment that produced LEM vehicle dynamics. This training gave Neil Armstrong and others the opportunity to safely experience the dynamics of lunar flight while in a controlled research environment. Experience gained at the Lunar Landing Research Facility enabled Neil Armstrong and others to train with a greater degree of confidence on the Lunar Research Training vehicle at Houston and Edwards Air Force Base and eventually to journey to the moon in July 1969.

The decision by President John F. Kennedy to land a man on the Moon by 1969 meant that NASA had to quickly determine the method of accomplishing the journey. NASA engineers evaluated three means to do this by 1962: direct ascent, Earth-orbit rendezvous (EOR), or lunar-orbit rendezvous (LOR).

Direct ascent to the moon was ruled out because of the size of the launch vehicle required to accomplish the mission. The EOR concept was ruled out because two launch vehicles were required to meet mission requirements. NASA chose the LOR concept which called for a single rocket to launch two spacecraft into lunar orbit where one would remain in orbit while the other would decend to the Moon. The vehicle on the Moon would then boost itself back into lunar orbit, rendezvous and dock with the mother ship, which would then return to the Earth.

While this was a bold plan that held out the promise of achieving a lunar landing by 1969 it presented many technical difficulties. The LOR plan was based on the premise that NASA trained astronauts could master the techniques of landing the LEM on the lunar surface and returning to orbit and docking with the mother ship. The Lunar Landing Research Facility was designed to solve one part of this problem, that is, how to land men on the surface of the Moon. The need for such a facility arose from the fact that there was no direct parallel between the unique piloting problems of the LEM and normal aircraft operating in Earth's atmosphere. Conditions encountered by the LEM were different due to the Moon's lack of an atmosphere and low gravitational force. For example, a vehicle operating in the vicinity of the Moon requires the use of control rockets which are operated in an on-off manner, thereby producing abrupt changes in control torques rather than the smoothly modulated controlled torques of a helicopter. Furthermore, inasmuch as the LEM hovers with a thrust equal to its weight, the lunar vehicle hovers with only one-sixth of the thrust required to hover the same vehicle in Earth's gravity. As a result, the control system characteristics in translation are markedly different from those of an Earth vehicle, thus precluding the extrapolation of results in Earth conditions to lunar conditions.[5]

9. Major Bibliographical References

See continuation sheets

10. Geographical Data

Acreage of nominated property Less than 1 acre

Quadrangle name Newport News North **Quadrangle scale** 1:24,000

UMT References

	Zone	Easting	Northing
A	18	376500	4101690
B			
C			
D			
E			
F			
G			
H			

Verbal boundary description and justification

The boundary of the Lunar Landing Research Facility is shown as the black circle on the accompanying map entitled "NASA, Langley Research Center, Figure 1-4, West Area."

List all states and counties for properties overlapping state or county boundaries

state	code	county	code
state	code	county	code

11. Form Prepared By

name/title Harry A. Butowsky

organization National Park Service **date** May 15, 1984

street & number Division of History **telephone** (202) 343-8168

city or town Washington, D.C. 20240 **state**

12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national ___ state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

State Historic Preservation Officer signature

title **date**

For NPS use only

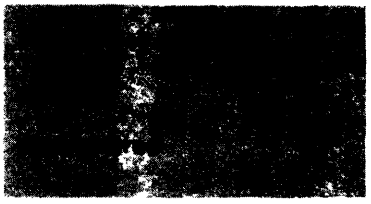
I hereby certify that this property is included in the National Register

date

Keeper of the National Register

Attest: 2.13 **date**

Chief of Registration



The Lunar Landing Research Facility was also used as a lunar-walking simulator for the Apollo astronauts. This was done by suspending the subject on his side so that he was free to generate walking movements on a plane inclined to about 80.5 degrees relative to the vertical direction of earth's gravity. Suspension for the test subject was supplied by a series of slings and cables attached to a lightweight trolly which traveled freely along an overhead track. By varying the angle of the inclined plane it was possible to simulate other gravitational fields. For example, to simulate the condition of weightlessness, the walkway would be moved directly under the track so that the cables were vertical and the test subject horizontal.[4]

The base of the Lunar Landing Facility was modeled with fill dirt to resemble the surface of the Moon. Pock-marked holes, pits and craters resemble the lunar landscape encountered by Apollo 11 when it landed on the Moon in July 1969.

The Lunar Landing Facility is intact and retains almost all of its design integrity. The facility is now known as the Impact Dynamics Research Facility and is used by NASA Langley for aircraft impact studies. The base of the facility has been modified so that the simulated lunar landscape is gone and has been replaced by an impact runway that can be modified to simulate various types of crash environments. The complex cable system that once carried the LEM now supports various test aircraft in crash studies. The lunar walkway has been removed. The LEM is on the site but the main engine and some of the controls have been removed. The original electronics associated with the site are in the process of being upgraded to meet modern requirements of the crash testing program.

An institutional rehabilitation of the office portion of the facility is now underway and will be completed by October 1, 1984.

Experiences gained by the Apollo astronauts on the Lunar Landing Research Facility indicated that it was possible to successfully master the complicated skills that were required to land the LEM on the Moon. Both Neil Armstrong and Edwin Aldrin trained there for many hours. Only when they successfully mastered skills necessary to fly the LEM would NASA approve plans for their historic first landing on the Moon in July 1969.

Because of this, the Lunar Landing Research Facility was an indispensable tool that enabled NASA to land a man on the Moon by July 1969.

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Footnotes

1. Donald E. Hewes, Reduced Gravity Simulator For Studies of Man's Mobility In Space And On The Moon. Report Presented at the Human Factors Meeting, Dayton, Ohio, October 18-21, 1965 (Hampton, Va.: Langley Research Center, 1965), p 3.

2. Ibid.

3. Ibid., 4.

4. Ibid., 1-2.

5. No Author Given, Lunar Landing Research Facility (Hampton, Va.: Langley Research Center, 1969), p. 1-2.

Bibliography

Benson, Charles D., and Faherty, William Barnaby. Moonport: A History of Apollo Launch Facilities and Operations. Washington D.C.: National Aeronautics and Space Administration, 1979.

Brooks, Courtney G.; Grimwood, James.; and Swenson, Jr., Loyd S. Chariots for Apollo: A History of Manned Lunar Spacecraft. Washington, D.C.: National Aeronautics and Space Administration, 1979.

Hewes, Donald E. Reduced Gravity Simulator For Studies of Man's Mobility In Space And On The Moon. Report Presented at the Human Factors Meeting Dayton, Ohio, October 18-21, 1965. Hampton, Va.: Langley Research Center 1965.

Levine, Arnold S. Managing NASA in the Apollo Era. Washington, D.C.: National Aeronautics and Space Administration, 1982.

Lunar Landing Research Facility. No Author Given. Hampton, Va.: Langley Research Center, 1969.

Morse, Mary Louise, and Bays, Jean Kernahan. The Apollo Spacecraft: A Chronology. Washington, D.C.: National Aeronautics and Space Administration, 1973.

Technical Facilities Catalog Vol.1. Washington, D.C.: National Aeronautics and Space Administration, 1974.

U.S. Congress. House, United States Civilian Space Programs A Report prepared for the Subcommittee on Space Science and Applications. Serial D, Vol. 1, January 1981.

Appendix A

ASTRONAUTS TRAINED AT LUNAR LANDING RESEARCH FACILITY

Armstrong, Neil A.

Aldrin, Edwin E., Jr.

Anders, William A.

Bean, Alan L.

Borman, Frank

Carr, Gerald P.

Cernan, Eugene A.

Chaffee, Roger

Cooper, L. Gordon, Jr.

Conrad, Charles

Duke, Charles M.

Engle, Joe N.

Haise, Fred W., Jr.

Irwin, James R.

Lovell, James A., Jr.

McDivitt, James A.

Mitchell, Edgar D.

Schmitt, Harrison H.

Schweickart, Russell L.

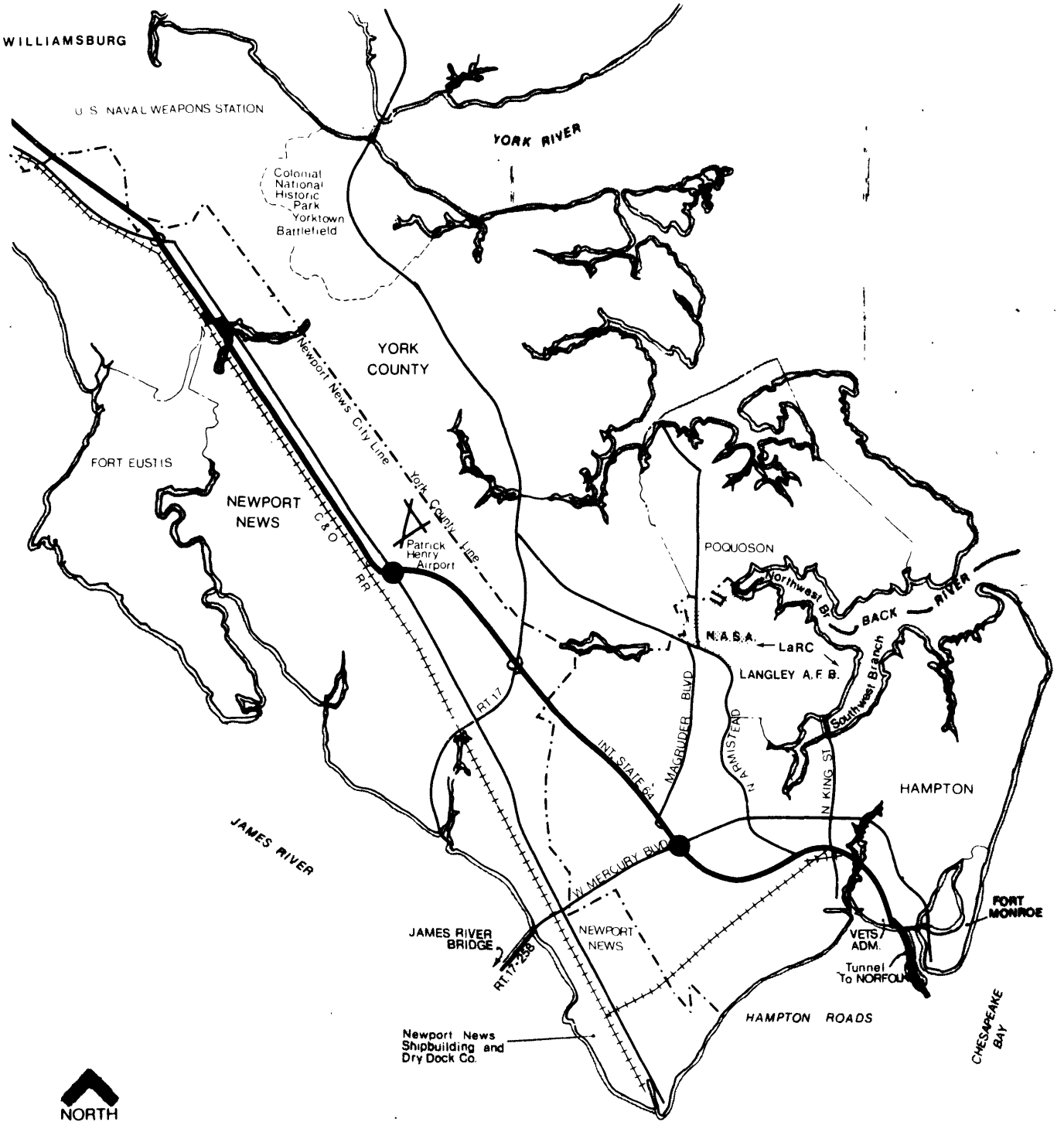
Scott, David R.

Shepard, Allen B., Jr.

Stafford, Thomas P.

Williams, C. C.

Young, John W.



NASA
National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia
23665

FIGURE 1-1
Regional Map

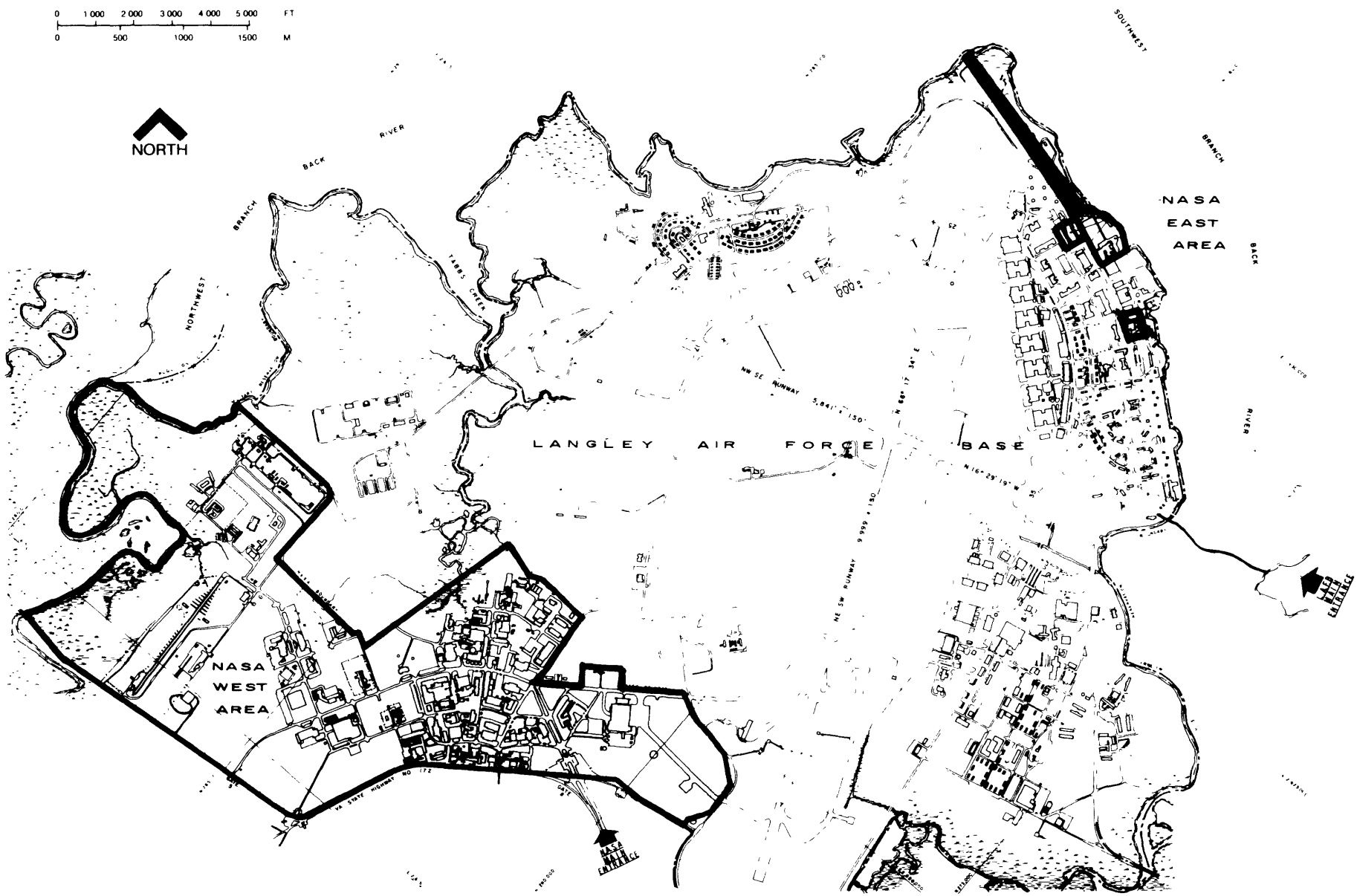


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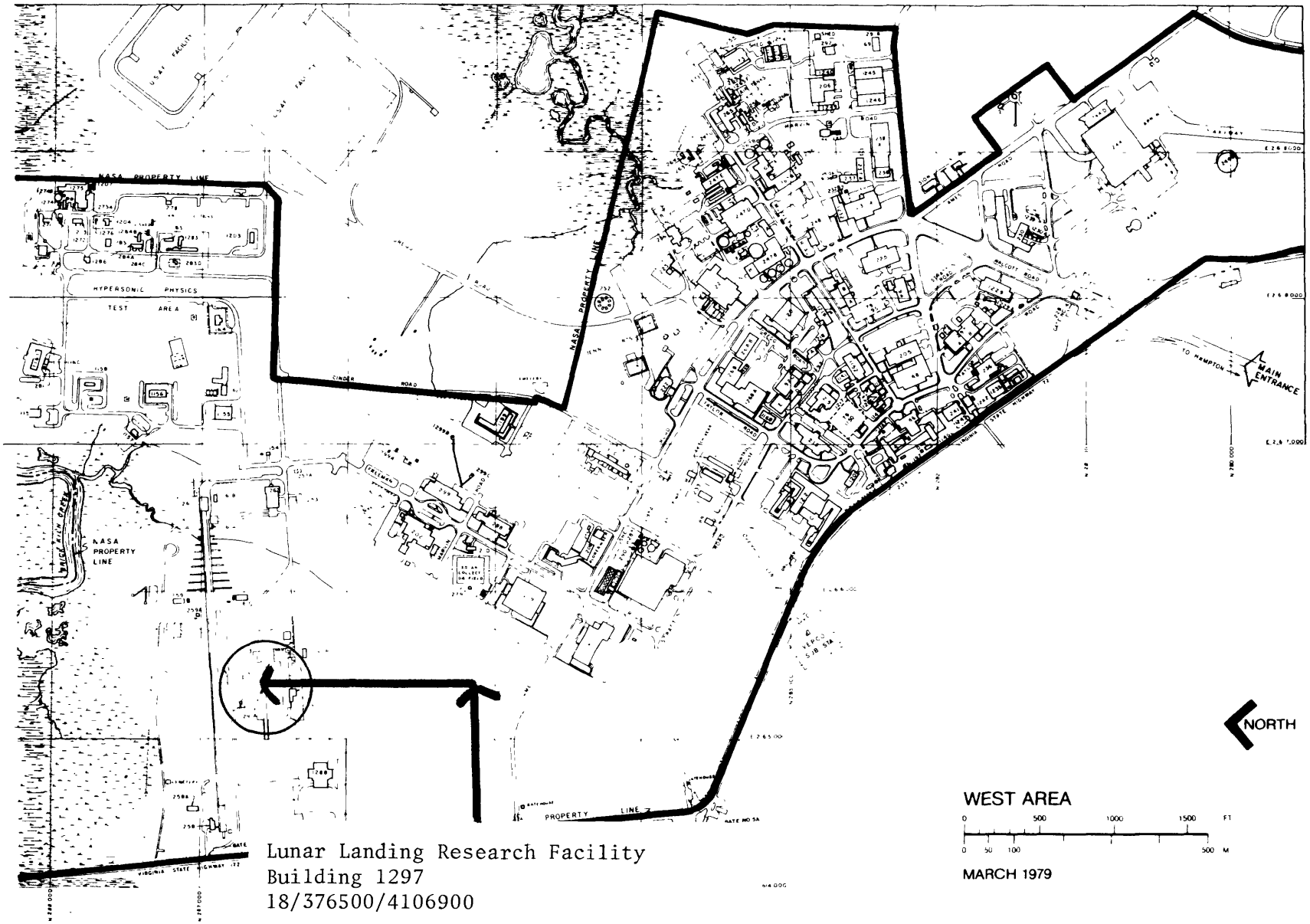
FIGURE 1-2
Combined East & West Area



Lunar Landing Research Facility
Building 1297
18/376500/4106900

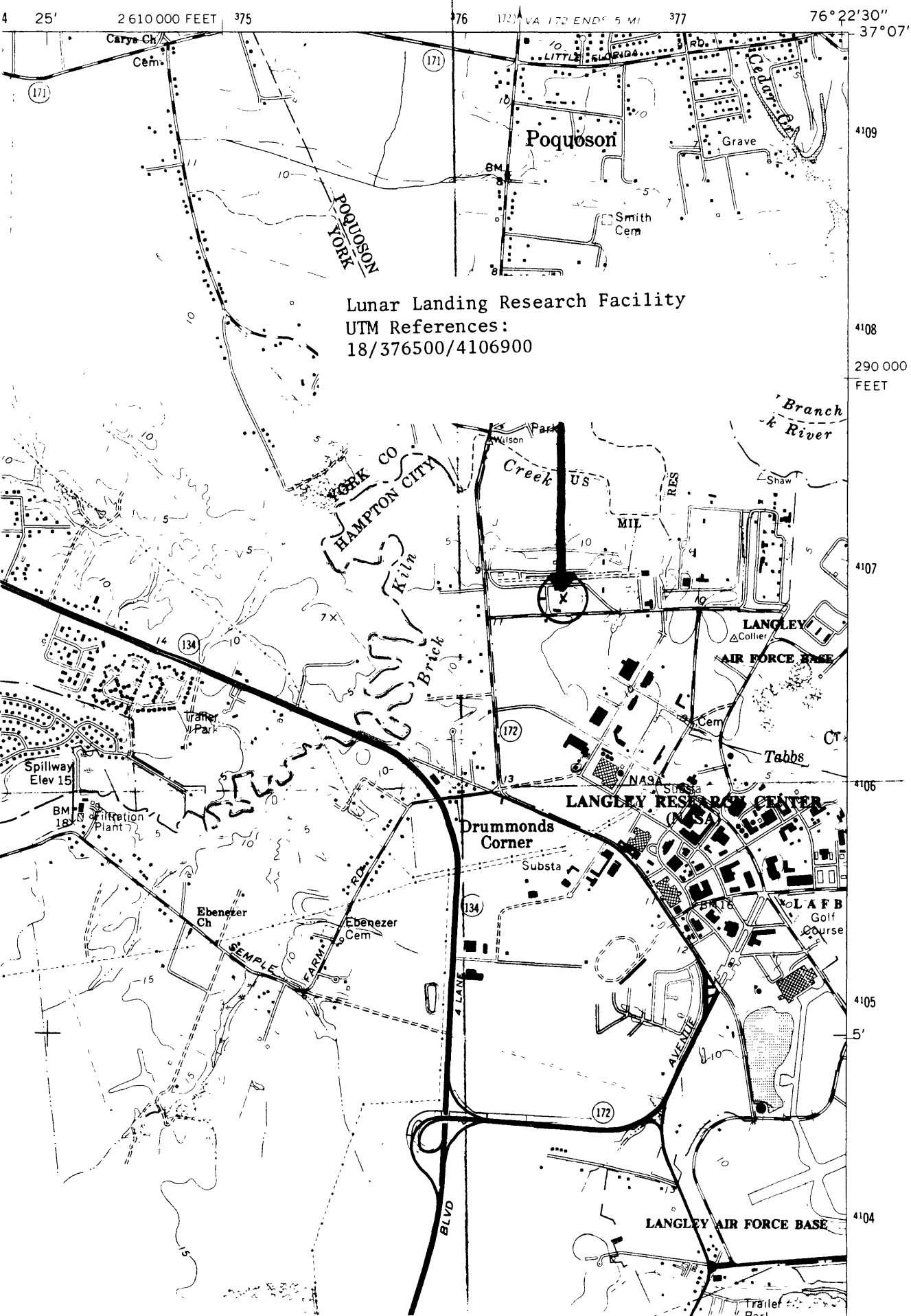
NASA
National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia
23665

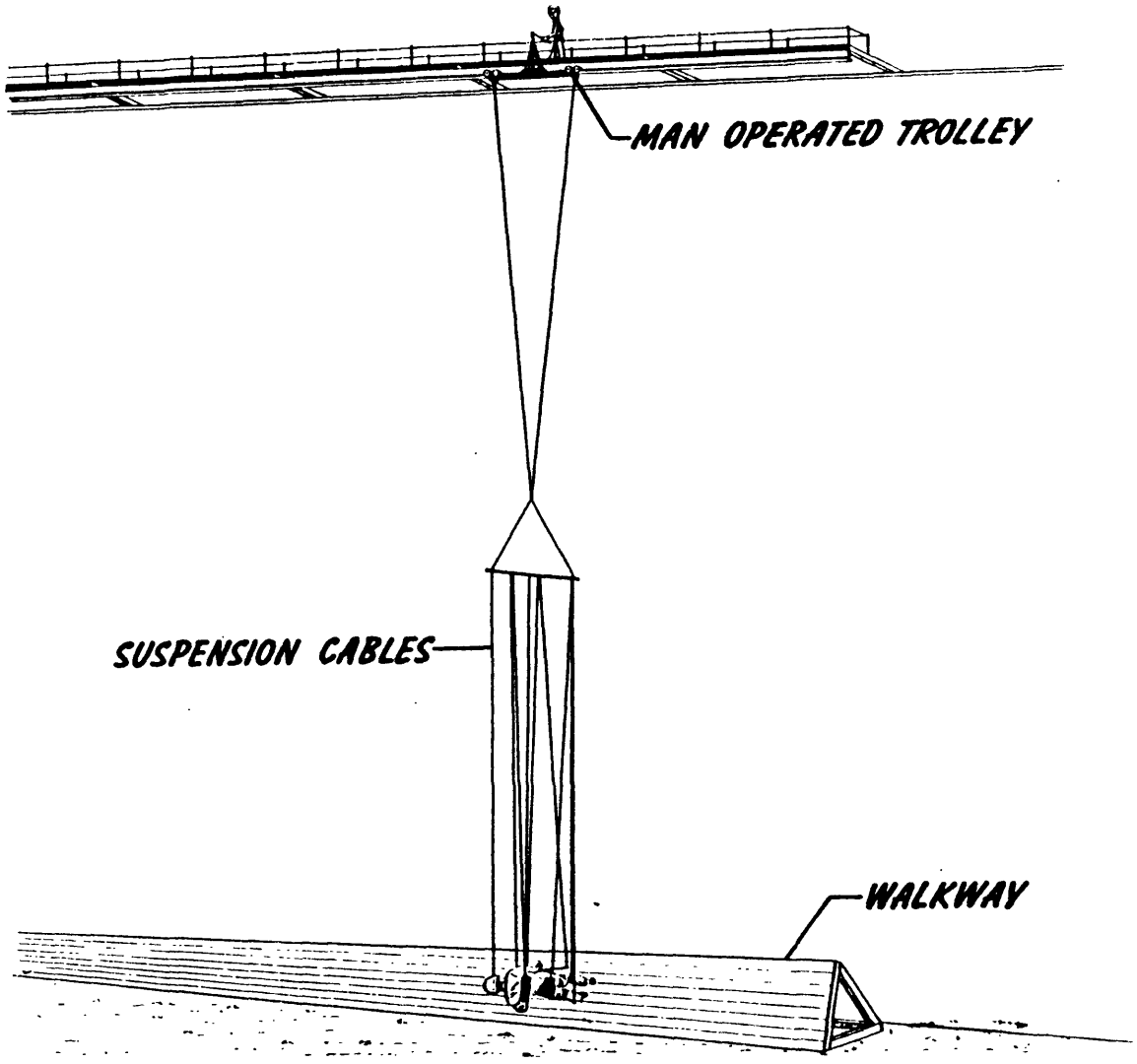
FIGURE 1-4
West Area

NEWPORT NEWS NORTH QUADRANGLE
VIRGINIA
7.5 MINUTE SERIES (TOPOGRAPHIC)

5758 III NE
(POQUOSON EAST)



MAN SELF-LOCOMOTION STUDIES



Sketch illustrating the lunar walking simulator.

Source: Hewes, p. 8.

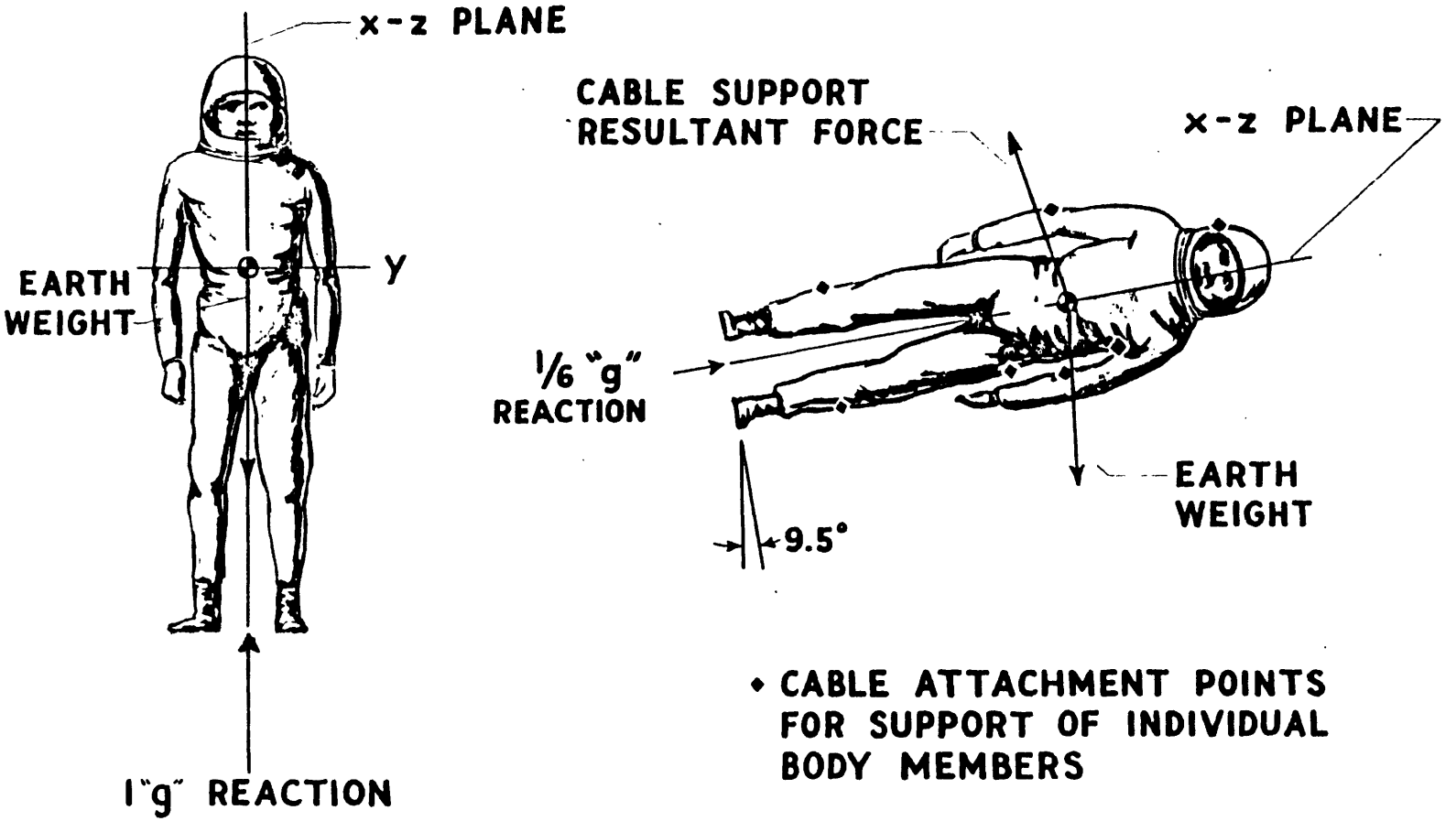


Illustration of lunar gravity simulation technique for self-locomotive studies.

Source: Hewes, p. 7.